

# **INDOOR AIR QUALITY ASSESSMENT**

**John J. Shaughnessy Elementary School  
1158 Gorham Street  
Lowell, MA 01852**



Prepared by:  
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## **Background/Introduction**

At the request of several faculty members, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at the Shaughnessy Elementary School (SES), 1158 Gorham Street, Lowell, Massachusetts. The request was prompted by concerns over cancer diagnoses among building occupants and any possible association with IAQ in the building. In addition, specific concerns by occupants regarding vapor intrusion from soil beneath and around the building were raised.

On May 4, 2005, a visit to conduct an indoor air quality assessment was made to the SES by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. During the assessment, Cathy Gallagher and Josh McHale, a Risk Communication Specialist and Environmental Analyst in CEH's Community Assessment Program (CAP), accompanied Mr. Holmes.

The SES is a two-story, red brick building constructed in 1991. The school consists of general classrooms, gymnasium, kitchen/cafeteria, library, computer rooms, art rooms and office space. Windows are openable throughout the building.

## **Methods**

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo

Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

## **Results**

The school houses approximately 500 pre-kindergarten through fourth grade students and approximately 80 staff members. The tests were taken during normal operations at the school. Test results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in twenty-one of forty-one areas, indicating inadequate air exchange in approximately one half of the areas surveyed. Fresh air in each classroom is mechanically supplied by a unit ventilator (univent) system (Picture 1). A univent draws air from outdoors through a fresh air intake located on an exterior wall of the building and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located on the top of the unit ([Figure 1](#)).

Several univents were found deactivated at the time of the assessment. The univents in classrooms A-118, A-124 and B-123 were reactivated by the school custodian; the univent in classroom A-125 had reportedly been deactivated due to chronic overheating. Obstructions to airflow, such as items on top of univents and tables and desks in front of univent returns were also observed in a few classrooms (Picture 3). To function as designed, univents must remain free of obstructions and allowed to operate.

Exhaust ventilation in classrooms consists of wall or ceiling-mounted vents connected to rooftop motors via ductwork (Pictures 5 and 6). These vents were operating in the majority of areas surveyed (Table 1). It was reported to MDPH staff that the Lowell Department of Public Works had previously been in the building to make ventilation upgrades to room A-203. These upgrades included increased exhaust ventilation and the addition of a supply vent that branches off a main duct. However, during the assessment, little or no draw could be detected from the wall-mounted exhaust vent. Without adequate exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air complaints.

Mechanical ventilation for interior rooms and common areas such as the gym and library is provided by air handling units (AHUs). Air is distributed through ducted wall or ceiling vents (Picture 5) and is returned to the AHUs by ducted wall or ceiling-mounted return vents. These systems were operating throughout the building on the day of the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing reportedly occurred in 1991.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or operable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the

temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix A](#).

Temperature measurements ranged from 68° F to 75° F, which were very close to the MDPH recommended comfort range the day of the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate

fresh air supply. Occupants in several areas voiced complaints of chronic heat and lack of temperature control, these included A-118, A-124 and the computer room (A-115).

The relative humidity measured in the building ranged from 23 to 33 percent, which was below the MDPH recommended comfort range the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

Plants were observed in several classrooms. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth.

Bushes/shrubbery were observed in close proximity to univent air intakes along the perimeter of the building (Picture 6). Plant growth in close proximity to univent air intakes can draw in allergens such as mold and pollen.

Clinging plants were observed on exterior brickwork (Picture 7). Clinging plants can cause water damage to brickwork by inserting tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in wall damage.

A few areas had water stained ceiling tiles, which can indicate leaks from the roof or plumbing system. Water damaged porous building materials can provide a source for mold and should be replaced after a water leak is discovered and repaired.

### **Other IAQ Evaluations**

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers ( $\mu\text{m}$ ) or less (PM<sub>2.5</sub>) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM<sub>2.5</sub>.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC

systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

*Carbon monoxide should not be present in a typical, indoor environment.* If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10  $\mu\text{m}$  or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ( $\mu\text{g}/\text{m}^3$ ) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particle levels be maintained below 65  $\mu\text{g}/\text{m}^3$  over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more



protective proposed PM<sub>2.5</sub> standard for evaluating airborne particulate matter concentrations in the indoor environment.

On the day of assessment, outdoor PM<sub>2.5</sub> concentrations were measured at 21 µg/m<sup>3</sup> (Table 1). PM<sub>2.5</sub> levels measured in the school ranged from 5 to 24 µg/m<sup>3</sup>, which were below or close to background levels (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted throughout the facility. In light of vapor intrusion concerns from occupants, TVOC screening was also conducted several inches above the ground, around the perimeter of the building. Measurements were additionally taken from storm drains and utility holes that may serve as pathways/sources of soil VOCs and/or odors. All outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations throughout the building were also ND.

In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no TVOCs were measured that exceeded background levels, materials containing VOCs were present in the school.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Several areas contain photocopiers and lamination machines. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). Lamination machines can produce irritating odors during use. These areas are equipped with local exhaust ventilation; occupants should ensure that vents are operating to help reduce excess heat and odors.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 8). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Also of concern are unlabelled bottles and containers. Products should be kept in their original containers and be clearly labeled for identification purposes, especially in the event of an emergency.

A strong fragrance was detected in classroom A-116. The source was a plug-in air freshener (Picture 9). Air fresheners contain chemicals that can be irritating to the eyes, nose

and throat of sensitive individuals. Furthermore, air fresheners do not remove materials causing odors, but rather mask odors that may be present in the area.

Periodic odors originating from open utility holes in the floor of the main office (Picture 10) were reported by occupants. Open utility holes in walls and/or floors can provide a means of egress for odors, fumes, dusts and vapors between rooms and floors. Although no odors were detected the day of the assessment, MDPH staff recommended that these utility holes be sealed.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 11). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as [Appendix B](#) (NIOSH, 1998).

Several other conditions that can affect indoor air quality were noted during the assessment. Accumulated dust was observed on supply and exhaust vents in the kitchen area (Picture 5). Vents should be cleaned periodically to prevent aerosolization of accumulated dust. At the time of the assessment, MDPH staff recommended cleaning/changing stained tiles around these vents and monitoring for further staining. Several reasons may exist for this dust/dirt accumulation on tiles in this area. Occupants reported that the filters for the

rooftop AHU that services this area had not been changed frequently, but was recently changed. Without cleaning/changing filters regularly the activation of the AHU can re-aerosolize dirt, dust and particulates, which can collect on ceiling tiles as a result of impaction from air movement from the vent. Secondly, MDPH staff observed that the boiler room doors were pegged open (Picture 12) and a sign was posted to leave doors open. With doors left open, fuel/boiler room odors and particulates from combustion (e.g., soot) can migrate into the hallway between the boiler room and the cafeteria.

## **Health Concerns**

In October 2002 the Center for Environmental Health (CEH) received a phone call from Frank Singleton, Director of the Lowell Board of Health, in regard to a suspected increase of cancer incidence among staff at the John Shaughnessy Elementary School in Lowell. During the telephone conversation, Mr. Singleton provided CAP staff with information about the types of cancers diagnosed among school staff (e.g., pancreatic, colorectal, ovarian, brain, and melanoma), but he did not have more specific diagnosis information (i.e., age and date of diagnosis). Based on the information provided by Mr. Singleton, CAP staff discussed the information in context with known information about cancer (i.e., several cancer types with risk factors not thought to be related to the environment, a number of different cancer types diagnosed among staff versus the same or similar types). However, CAP staff also informed Mr. Singleton that any staff at the Shaughnessy School could contact the CAP to discuss their concerns and/or provide more specific diagnosis information.

In February 2005, the CAP received a telephone call from a teacher at the Shaughnessy School who was concerned about a suspected increase of cancer among staff at the school and whether or not these diagnoses of cancer could be related to something in the building. In addition, the teacher thought that the property where the school had been built was used as a former landfill. In order to further investigate concerns at the school, CAP staff asked the teacher to submit a written request to the CEH that contained information on each current and former staff member diagnosed with cancer including primary site of cancer, approximate age and date of diagnosis, and approximate dates of employment at the Shaughnessy School. This request for written documentation is consistent with the CEH protocol for conducting environmental health assessments.

In March 2005, the CEH received information from the teacher at the Shaughnessy School on four staff members who had been diagnosed with cancer while working at the Shaughnessy School. Name, primary site of cancer, approximate age and date of diagnosis were reported for all four individuals. Although the number of years that each staff member had worked at the school was reported, approximate dates of employment were not provided for any of the individuals. Finally, a date of death was provided for two of the four staff members who had passed away. During a May 4, 2005 inspection of the Shaughnessy School by the CEH's Indoor Air Quality Program (IAQ), staff at the school supplied the names of four additional staff members who had been diagnosed with cancer. At this time, diagnosis information (e.g., primary site of cancer, approximate date and age of diagnosis), dates of employment at the school and location in the building where each staff member worked was provided for all eight staff members reported to the CEH with a diagnosis of cancer.

CAP staff reviewed the most recent data available from the Massachusetts Cancer Registry (MCR) to confirm cancer diagnoses reported among Shaughnessy School employees and to determine whether these diagnoses may represent an unusual pattern of cancer incidence. The MCR, a division within the MDPH Center for Health Information, Statistics, Research and Evaluation, is a population based surveillance system that has been monitoring cancer incidence in the Commonwealth since 1982. All new diagnoses of invasive cancer, along with several types of in situ (localized) cancer, occurring among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111. s 111b). Some non-cancerous (i.e., benign) tumors of the brain and CNS are reported to the MCR; however, benign tumors of other organs are not included in the MCR data files. This information is collected and kept in a confidential database. Data are collected on a daily basis and reviewed for accuracy and completeness on an annual basis. This process corrects misclassification of data (i.e., city/town misclassification) and deletes duplicate case reports.

CAP staff were able to confirm cancer diagnoses for all eight of the individuals through the MCR. Overall, eight different primary cancer diagnoses were confirmed among these eight individuals including cancers of the brain, colon, ovary, prostate, and liver, as well as malignant melanoma and two other less common types. For one individual, the type of cancer confirmed in the MCR was different from that reported to the CEH. Based on the current scientific and medical literature, the eight different cancer types diagnosed among Shaughnessy employees are not thought to share common risk factors related to their development. No atypical pattern of any one cancer type was noted. The eight staff members were diagnosed over a ten-year time period indicating no apparent trend in diagnoses over

time. Three of the cancer types diagnosed among school employees are among the most commonly diagnosed cancers among residents in Massachusetts and in the U.S. as a whole.

One of these eight individuals has been diagnosed with multiple primary sites of cancer while working at the Shaughnessy School. Patients who receive radiation therapy for other cancers can develop the secondary type of cancer diagnosed in this individual. This individual may have received radiation therapy for his or her initial cancer that could have contributed to their subsequent diagnosis of cancer. However, using MCR data, it is not possible to determine whether this individual actually received radiation treatment for his or her first cancer diagnosis.

Although it is not possible to determine what may have caused any one person's diagnosis with cancer, the length of time in which an individual worked in a particular building can help determine the importance that their location might have in terms of exposure to a potential environmental source. Cancer in general has a long period of development or latency period (i.e., the interval between first exposure to a disease-causing agent and the appearance of symptoms of the disease [Last 1995]) that can range from 10 to 30 years and in some cases may be more than 40 to 50 years for solid tumors (Bang 1996; Frumkin 1995). Because of this, past exposures are more relevant than current exposures as potential risk factors for cancers. Based on information provided from staff at the Shaughnessy School approximate length of employment for the 8 individuals confirmed in the MCR was evaluated. The majority, 6 of 8 staff members, worked in the school between 6 and 10 years prior to their diagnosis of their primary site cancer. Two individuals worked at the school less than 5 years prior to diagnosis of their first primary site cancer. Although one staff person with a cancer diagnosis has been employed at the school for over 10 years, their

first diagnosis was made during their first 6 to 10 years of employment. The relatively short time period between possible exposure at the Shaughnessy School and diagnosis of cancer indicates that it is less likely that an exposure at the school is related to the diagnosis of cancer.

Another concern expressed by employees at the school focused on the prior use of the land on which the Shaughnessy School now resides. According to some Shaughnessy employees, the land where the school was built was reportedly used as a landfill prior to 1950. CAP staff reviewed available Sanborn Fire Insurance Maps<sup>1</sup> for the City of Lowell dating from the early 20<sup>th</sup> century to determine if any buildings may have been on the property before the school (Sanborn, 1950). A review of land records available at the Middlesex North Registry of Deeds in Lowell was also conducted to try and trace ownership of the land. According to the Sanborn maps, in the early part of the 20<sup>th</sup> century, prior to 1910, the land was used by the Middlesex North Agricultural Society as a fairground for the society. Located on the property were a grandstand, a ticket office and stables for various livestock. According to information at the Middlesex North Registry of Deeds, between 1910 and 1920 the land was divided into smaller lots and some lots were sold by the Northern Land Company to private individuals. Then, around 1920, the City of Lowell acquired all of the remaining property as well as the lots that had been sold to private citizens. The site became the property of the Lowell School Department and a school was first build on the site in the mid 1950's. From the available information there does not appear to have been any industrial

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<sup>1</sup> Sanborn Fire Insurance Maps are produced to assist insurance agents in risk-assessment for areas with high property value. They provide a highly-detailed account of urban development and change in American communities during the early twentieth century. Sanborn maps are large-scale and depict street layouts, building footprints, building materials, utility lines and other details.



buildings on the property. Also the Massachusetts Department of Environmental Protection (MDEP), which oversees the regulation of waste sites in the state, has no information on the property. From the information that was reviewed, there is no reason to suspect the presence of any unknown illegal disposal of waste on the property, either by individuals or companies.

Staff at the school mentioned concerns of vapor intrusion from underground water sources. Vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and/or contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas seeping into homes. Two waste sites [Silresim (Tanner Avenue) and Costa's Landfill (Billerica Street)] were mentioned by staff as possible sources of contamination. The school is three-quarters of a mile from the Silresim site. The extent of groundwater contamination at Silresim was determined to be within less than a quarter mile of the site (ATSDR, 1995). In addition the flow of groundwater was determined to be toward the north and northwest of Silresim, away from the Shaughnessy School (EPA, 2004). Further, according to the United States Environmental Protection Agency (EPA) and Agency for Toxic Substances and Disease Registry (ATSDR), remediation at the site is ongoing and expected to prevent the spread of contaminated groundwater. Specific information on the nature and extent of contamination at the Costa's Landfill (located a half mile from the school) was unavailable (MDEP, personal communication). However the school is located at a higher elevation and on the opposite side of the Concord River indicating that possible exposure to groundwater vapor related to the landfill is highly unlikely to occur at the Shaughnessy School.

When reviewing this information it is important to keep in mind that cancer is a common disease. The American Cancer Society estimates that one out of every three Americans will develop some type of cancer during his or her lifetime. Over the past forty years, the rise in the number of cancer cases generally reflects the increase in the population, particularly in the older age groups. Although most cancer types occur more frequently in older populations (i.e. age 50 and over), cancer can affect people of all ages. The most commonly diagnosed cancers for adult males include cancers of the prostate, lung and bronchus, and colon. Breast, lung and bronchus, and colon cancers are the most common cancer types diagnosed among females (ACS, 2005).

Understanding that cancer is not one disease, but a group of diseases, is also very important. Research has shown that there are more than 100 different types of cancer, each with different causative (or risk) factors. In addition, cancers of a certain tissue type in one organ may have a number of causes. Cancer may also be caused by one or several factors acting over time. For example, tobacco use has been linked to lung, bladder, and pancreatic cancers. Other factors related to cancer may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important risk factor for several cancers. In addition, some occupational exposures, such as jobs involving regular contact with asbestos, have been shown to cause specific cancers (e.g., asbestos exposure can cause mesothelioma). Environmental contaminants have also been associated with certain types of cancer (Bang, 1996; Frumkin, 1995).

According to American Cancer Society statistics, cancer is the second leading cause of death in Massachusetts and the United States. Not only will one out of three people develop cancer in their lifetime, but this tragedy will affect three out of every four families. For this

reason, cancers often appear to occur in “clusters,” and it is understandable that people may perceive that there are an unusually high number of cancer cases in their workplace, surrounding neighborhoods or towns. Upon close examination, many of these “clusters” are not unusual increases, as first thought, but are related to such factors as local population density, variations in reporting or chance fluctuations in occurrence. In other instances, the “cluster” in question includes a high concentration of individuals who possess related behaviors or risk factors for cancer. Some concentrations of disease, however, are unusual; that is, they represent a true excess of cancer in a workplace, a community, or among a subgroup of people. A suspected cluster is more likely to be a true cancer cluster if it involves a large number of cases of one type of cancer diagnosed in a relatively short time period rather than several different types diagnosed over a long period of time (i.e., 20 years), a rare type of cancer rather than common types, and/or a large number of cases diagnosed among individuals in age groups not usually affected by that cancer. These types of clusters may warrant further public health investigation.

Based upon our review of the available diagnosis information, as well as the most current cancer literature, there does not appear to be an atypical pattern of cancer diagnoses among current and former employees of the Shaughnessy Elementary School in Lowell. That is, it does not appear that a common factor (either environmental or non-environmental) is likely related to diagnoses of cancer among these individuals. Among the eight individuals whose diagnosis was confirmed in the MCR there were eight different cancer types identified indicating no atypical pattern of any one cancer type. Finally, while potential indoor air quality problems have been investigated at this school, these issues are not likely to be related to the incidence of cancer among employees at Shaughnessy, but probably have contributed

to common symptoms associated with poor indoor air quality (e.g., headaches, irritant symptoms).

## **Conclusions/Recommendations**

The conditions noted at the SES raise a number of indoor air quality issues. In addition to the IAQ assessment, MDPH staff also evaluated information in an attempt to identify possible environmental sources that have been suggested to play a role in the cancer development. No evidence of environmental sources associated with the disease were identified in or around the building. A number of minor issues regarding general building conditions, design and routine maintenance that can affect indoor air quality were observed. These factors can be associated with a range of IAQ related health and comfort complaints (e.g., eye, nose, and respiratory irritations), but they are unlikely to be associated with cancer occurrences among employees. In view of the findings at the time of the visit, the following recommendations are made:

1. Operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to “high”.
2. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
3. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance

department/ building management in a manner that allows for a timely remediation of the problem. An example is included as Appendix C.

4. Continue to examine the exhaust system in A 203 for proper function and air exchange. Make repairs/adjustments as needed.
5. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
6. Close classroom doors to improve air exchange.
7. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
9. Ensure all roof leaks are repaired, and replace water damaged ceiling tiles. Examine the area above and around water-damaged areas for mold growth. Disinfect areas with an appropriate antimicrobial as needed.
10. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources and carpeted areas.
11. Remove plants growing against building and its foundation to prevent water intrusion through brickwork.

12. Seal breaches around pipes and other spaces between rooms and floors (e.g., the main office) to prevent movement of crawlspace odors and particles.
13. Change filters for *all* air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
14. Ensure boiler room doors remain closed. Consider installing a door sweep or weather-stripping to prevent the movement of odors and particulates into adjacent areas.
15. Clean/change stained ceiling tiles in kitchen and surrounding areas and monitor for further staining.
16. Clean exhaust/return vents periodically to prevent excessive dust build-up.
17. Refrain from using strongly scented materials (e.g., air fresheners) in classrooms.
18. Ensure local exhaust ventilation is activated in areas with photocopiers and lamination machines, or relocate to a well-ventilated area.
19. Consider discontinuing the use of tennis balls on chair legs to prevent latex dust generation. See Picture 13 for an example of an alternative glide.
20. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled in case of emergency.
21. Consider adopting the US EPA (2000b) document, Tools for Schools, in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
22. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials

are located on the MDPH's website at

<http://www.state.ma.us/dph/beha/iaq/iaqhome.htm>.

## References

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**Picture 1**



**Classroom Univent**

**Picture 2**



**Univent Fresh Air Intake**

**Picture 3**



**Classroom Items around Univent Impeding Airflow**

**Picture 4**



**Ceiling-Mounted Exhaust Vent and Proximity to Hallway Door**

**Picture 5**



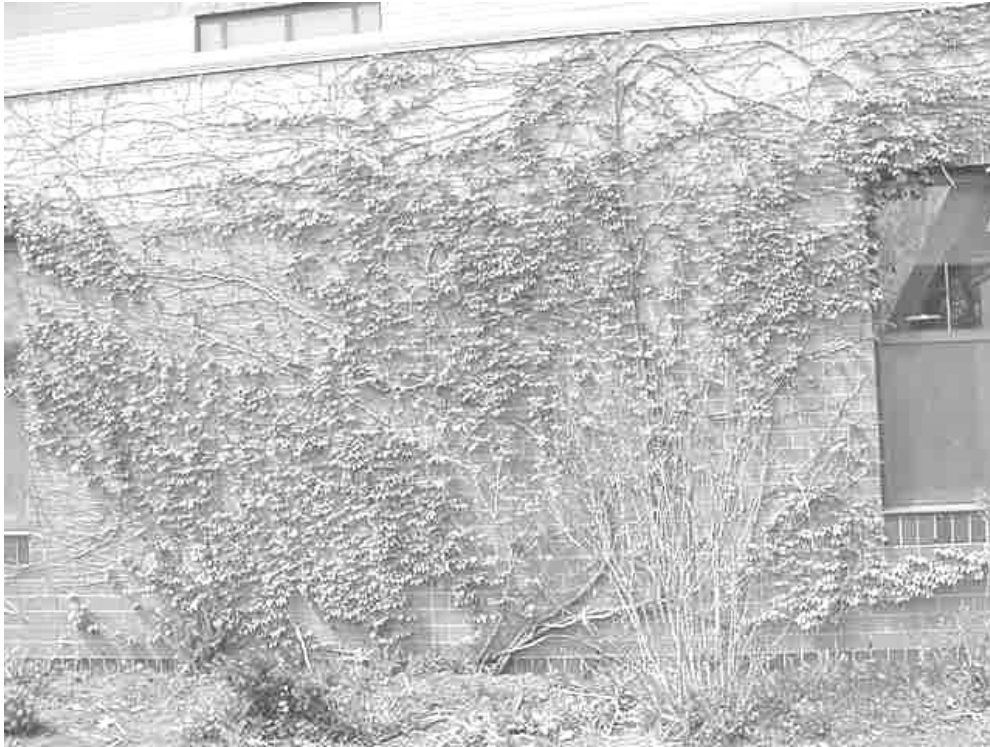
**Ceiling-Mounted Supply Vent, Note Dark Staining on Ceiling Tile around Vent**

**Picture 6**



**Bushes/Shrubbery in Close Proximity to Univent Air Intakes**

**Picture 7**



**Clinging Plants on Exterior Wall**



**Picture 8**



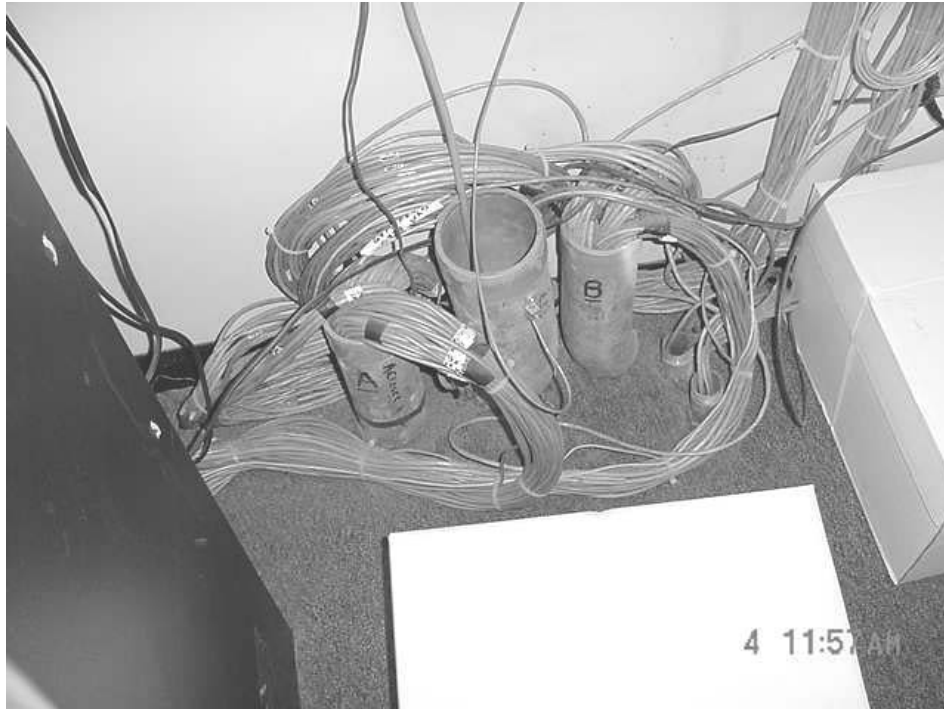
**Spray Cleaning Bottles on Sink Countertop**

**Picture 9**



**Plug-In Air Freshener in Classroom**

**Picture 10**



**Open Utility Pipes in Main Office**

**Picture 11**



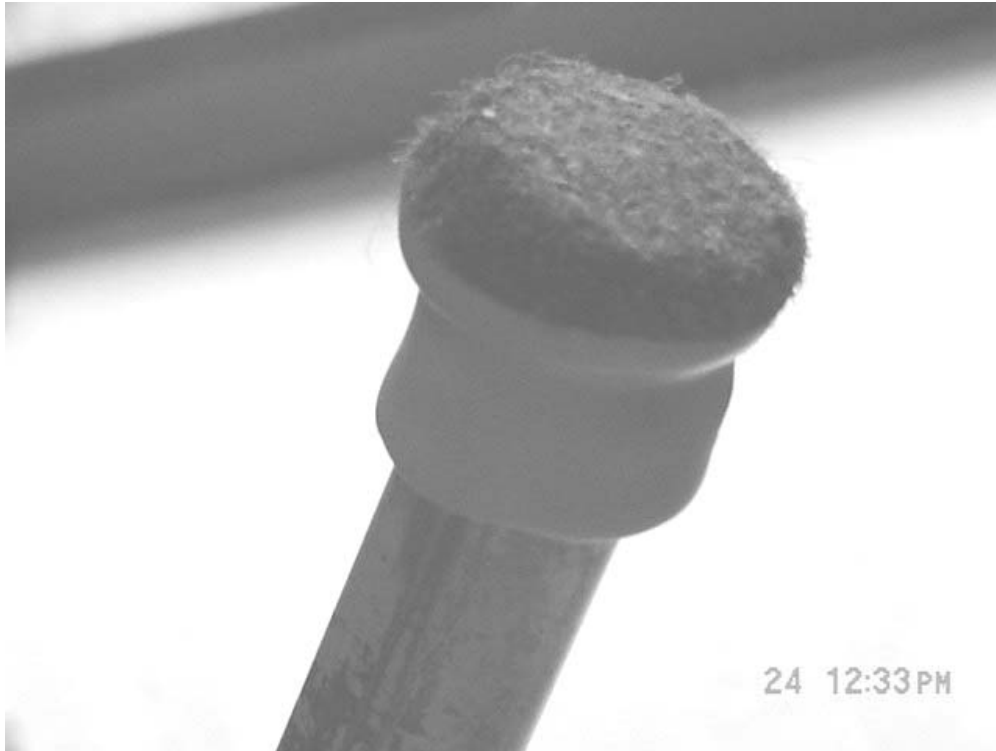
**Tennis Balls on Chair Legs**

**Picture 12**



**Open Boiler Room Doors near Cafeteria**

**Picture 13**



**“Glides” for Chair Legs that can be used as an Alternative to Tennis Balls**

**Table 1**

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background		60	29	342	ND	ND	21	N # open: 0 # total: 0			Comments: Mostly sunny, TVOC along north, south, east and west sides of the building = ND, TVOCs measured in storm drains (south and west) = ND.
B 214	1	70	28	716	ND	ND	10	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM, PF, Comments: 22 occupants gone 1 hour
B 213	22	72	29	1007	ND	ND	13	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, #WD-CT : 1, DEM
B 206	1	72	27	645	ND	ND	9	Y # open: 0 # total: 3	Y ceiling	Y ceiling	Hallway DO

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

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ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

WD = water damage

WP = wall plaster

**Comfort Guidelines**

Carbon Dioxide: < 600 ppm = preferred  
600 - 800 ppm = acceptable  
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F  
Relative Humidity: 40 - 60%

Table 1-1

**Table 1**

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
A 200	0	74	25	830	ND	ND	13	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM, cleaners, Comments: occupants gone 1 hour
A 201	22	71	23	741	ND	ND	19	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM, cleaners, Comments: cleaning odors
A 202	0	72	22	789	ND	ND	10	N # open: 0 # total: 0	Y ceiling	Y wall	Hallway DO
A 203	3	71	27	785	ND	ND	13	Y # open: 0 # total: 2	Y wall	Y wall (off) (weak)	Hallway DO, PF
A 117	21	73	28	1130	ND	ND	13	N # open: 0 # total: 0	Y ceiling	Y wall	PF, cleaners

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									Supply	Exhaust	
Nurse	2	73	28	873	ND	ND	12	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO
A 116	9	74	28	1136	ND	ND	19	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO, cleaners, plug-in, Comments: strong fragrance odors
A 118	11	74	30	1419	ND	ND	24	Y # open: 0 # total: 3	Y univent (off)	Y wall	DEM, Comments: UV reactivated by custodian
A 124	1	71	27	610	ND	ND	12	N # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO
Library	0	71	26	513	ND	ND	9	N # open: 0 # total: 0	Y wall	Y wall	Inter-room DO

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									Supply	Exhaust	
Teachers' Workroom	0	73	26	597	ND	ND	9	N # open: 0 # total: 0	Y ceiling	N	PC, laminator
A 113	1	72	29	960	ND	ND	12	Y # open: 0 # total: 0	Y univent	Y wall	Hallway DO, DEM, Comments: 20 occupants gone 15 min
A 109	24	73	31	1101	ND	ND	13	Y # open: 0 # total: 2	Y univent	Y wall	DEM
Computer Room	21	75	29	1132	ND	ND	9	N # open: 0 # total: 0	Y ceiling	Y wall	Comments: 30 + PCs, overheating/chronic heat issues
A 111	23	71	30	1088	ND	ND	21	Y # open: 0 # total: 6	Y univent	Y wall	Hallway DO, DEM, Comments: UV-rattling noise

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									Supply	Exhaust	
A 108	1	72	29	790	ND	ND	11	N # open: 0 # total: 0	Y		Hallway DO
A 124	0	71	30	1050	ND	ND	19	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO, Comments: UV reactivated by custodian
A 125	23	70	30	937	ND	ND	18	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO, DEM, cleaners, plug-in, Comments: UV deactivated due to overheating
B 130	20	70	29	787	ND	ND	16	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, PF, TB
B 123	2	70	30	892	ND	ND	17	Y # open: 0 # total: 30	Y univent (off)	Y wall	Hallway DO, DEM, Comments: 20 occupants gone 20 min, UV reactivated by custodian

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									Supply	Exhaust	
A 204	0	71	28	860	ND	ND	8	N # open: 0 # total: 0	Y ceiling		Comments: students in hallway for lunch
A 208	1	72	28	843	ND	ND	10	Y # open: 0 # total: 2	Y wall	Y wall	Hallway DO, Comments: 22 occupants gone 50 min
A 209	0	73	29	1200	ND	ND	12	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM
A 210	23	74	26	967	ND	ND	21	Y # open: 0 # total: 3	Y univent items		Hallway DO, DEM
Gym	24	72	27	620	ND	ND	5	N # open: 0 # total: 0	Y ceiling	Y wall	

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									Supply	Exhaust	
B 131	26	71	33	1373	ND	ND	23	Y # open: 0 # total: 3	Y univent (off)	Y wall	Hallway DO, DEM, TB
Boiler Room	0	68	27	445	ND	ND	15	N # open: 0 # total: 0	Y wall	N	Hallway DO
Custodian	0	69	27	631	ND	ND	15	Y # open: 0 # total: 0	Y ceiling	N	
B 203	1	72	24	570	ND	ND	11	N # open: 0 # total: 0	Y ceiling	Y wall	Hallway DO, #WD-CT: 1, Comments: mechanical exhaust vent in closet
B 200	2	71	26	692	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	Y wall	Hallway DO

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									Supply	Exhaust	
B 205	19	72	26	802	ND	ND	15	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM, plants
B 204	24	74	29	1166	ND	ND	12	Y # open: 0 # total: 3	Y univent	Y wall	Hallway DO, DEM
Cafeteria	100	70	28	734	ND	ND	18	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO
B 110 Kitchen Office	1	71	27	722	ND	ND	15	N # open: 0 # total: 0	Y ceiling dust/de bris	N	Hallway DO, Comments: Dust/dirt stained ceiling tiles around supply vent
A 211	25	73	26	785	ND	ND	10	Y # open: 0 # total: 2	Y wall plant(s)	Y wall	Hallway DO, DEM, PF, plants

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									Supply	Exhaust	
Main Office	2	71	26	550	ND	ND	13	N # open: 0 # total: 0	Y ceiling	Y wall	PC, Comments: open utility holes-floor (occasional odors reported by occupants)
Principal's Office	1	72	27	741	ND	ND	10	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO
Assistant Principal's Office	2	71	28	852	ND	ND	9	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, plants

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